

Investigating the Effects of Temperature on the Signatures of Shocks Propagated Through Impacts into Minerals Found in Comets and Asteroids

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Comets and asteroids are subjected to extremely cold conditions throughout their lifetimes. During their sojourns in the solar system, they are subjected to collisions at speeds that are easily capable of generating shock waves in their constituent materials. In addition to ices, more common silicate minerals such as olivines and pyroxenes are important components of these objects. The collision-induced shocks could affect the spectral signatures of those mineral components, which could in turn be detected telescopically. We have embarked on a project to determine how impact-generated shock might affect the reflectance spectra and structures of select silicates as both impact speed and target temperature are varied systematically.

While the effects of impact speed (in the form of shock stress) on numerous materials have been and continue to be studied, the role of target temperature has received comparatively little attention, presumably because of the operational difficulties it can introduce to experimentation. Our experiments were performed with the vertical gun in the Experimental Impact Laboratory of the Johnson Space Center. A liquid-nitrogen system was plumbed to permit cooling of the target container and its contents under vacuum to temperatures as low as -100°C (173 K). Temperatures were monitored by thermocouples mounted on the outside of the target container. Because those sensors were not in contact with the target material at impact, the measured temperatures are treated as lower limits for the actual values. Peridot (Mg-rich olivine) and enstatite (Mg-rich orthopyroxene) were used as targets, which involved the impact of alumina (Al₂O₃) spheres at speeds of 2.0 – 2.7 km s⁻¹ and temperatures covering 25°C to -100°C (298 K to 173 K). We have begun collecting and analyzing data in the near to mid-IR with a Fourier-transform infrared spectrometer, and preliminary analyses show that notable differences in absorption-band strength and position occur as functions of both impact speed (peak shock stress) and initial temperature.

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